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Review

Is surgical site scrubbing before painting of value? Review and meta-analysis of clinical studies

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SUMMARY

Background: Surgical site infections are major surgical complications. Surgical site scrubbing before painting is controversial.
Aim: To conduct a meta-analysis of clinical trials that compared pre-operative scrubbing before painting with painting alone for the prevention of surgical site infections.
Methods: A systematic review and meta-analysis of clinical trials in Pubmed, ScienceDirect and Cochrane databases that compared pre-operative scrubbing before painting with painting alone, and reported surgical site infections, skin colonization or adverse effects as an outcome, was undertaken. A fixed-effect model and a random-effect model were tested. Sensitivity analysis was conducted by removing non-randomized controlled trials.
Findings: The systematic review identified three studies, involving 570 patients, for surgical site infection outcomes, and four other studies, involving 1082 patients, for positive skin culture outcomes. No significant differences were observed between scrubbing before painting vs painting alone in terms of surgical site infection or positive skin culture.
Conclusion: Further research is needed to draw conclusions. Only one study in this meta-analysis identified adverse effects, but there were too few events to compare the various methods. It is believed that there is no need to scrub the surgical site if the skin is visibly clean and/or if the patient has had a pre-operative shower.

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Introduction

Surgical site infections are major surgical complications. Surgical site infections were found to be the third leading cause (14%) of hospital-acquired infections in the French national nosocomial infection prevalence survey conducted in 2006.[1] A French surveillance network reported an incidence rate of 0.93% for surgical site infections.[2] Contamination of a surgical site may occur through an endogenous mechanism, when the infection is due to a micro-organism coming from the patient themselves, or through an exogenous mechanism, when the micro-organism comes from the surgical team or the patient's environment. A number of measures can be undertaken to prevent endogenous infections, including skin preparation (pre-operative shower or bath, skin scrub and/or painting), antibiotic prophylaxis, peri-operative normothermia and blood sugar control.[3–7] Ultraclean air systems, surgical clothes and surgical cleaning procedures can be used for the prevention of exogenous infections.[3–7] Surgical site infections are classified into three categories: superficial, deep and organ/space infections.[4] Superficial surgical site infections are the most common, and are mainly due to an endogenous mechanism from the patient's skin.[2] Surgical site scrubbing aims to reduce the patient's flora and thus prevent endogenous contamination. It consists of vigorously scrubbing the surgical site with antiseptic soap. Recommendations for surgical site scrubbing vary between countries. Until the end of 2013, French recommendations were in favour of surgical scrubbing.[8] This is not the case in the UK or the USA.[3–7] The scrubbing technique may release micro-organisms from the skin pores and hair follicles, and thus may not have the expected effect.[9] Its effectiveness is therefore questioned, particularly since publication of a randomized controlled trial by Ellenhorn *et al.* (2005).[10] This study concluded that painting alone was not inferior to scrubbing before painting. However, this study has been criticized for using an excessively wide equivalence margin.[11] This resulted in a number of patients which was too small to reject equivalence if the absolute difference was >6%. Scrubbing is therefore controversial, especially as it is time-consuming. Other studies are available, but they are too small to be conclusive.[9,12] As such, a meta-analysis of the published comparative studies regarding scrubbing before painting was undertaken. The authors first examined studies conducted to prevent surgical site infections, and then examined studies concerning the prevention of positive skin cultures. The secondary objective was to analyse the side-effects of scrubbing before painting compared with painting alone.

Methods

Data sources

Pubmed, ScienceDirect and Cochrane databases were searched for articles published before February 2014 containing the term 'scrub*' combined with 'surgical site infection' or 'surgery' and 'infection' or 'postoperative infection'. No date or language restrictions were applied. As few studies were found, the search was expanded to include skin colonization as an outcome. Skin colonization was considered to be an indirect criterion for surgical site infection, and a complementary search using the terms 'scrub*' and 'skin' and 'colonization' was performed. A manual search of the bibliographies of the selected articles was also undertaken.

Selection

Only original articles comparing pre-operative skin scrubbing for the prevention of surgical site infections with similar interventions were selected. Randomized controlled trials and non-randomized trials were included, but other types of studies, such as literature reviews and outbreak investigations, were excluded.

Quality

Two researchers independently assessed the study limitations for each selected article according to the GRADE (Grading of Recommendations Assessment, Development and

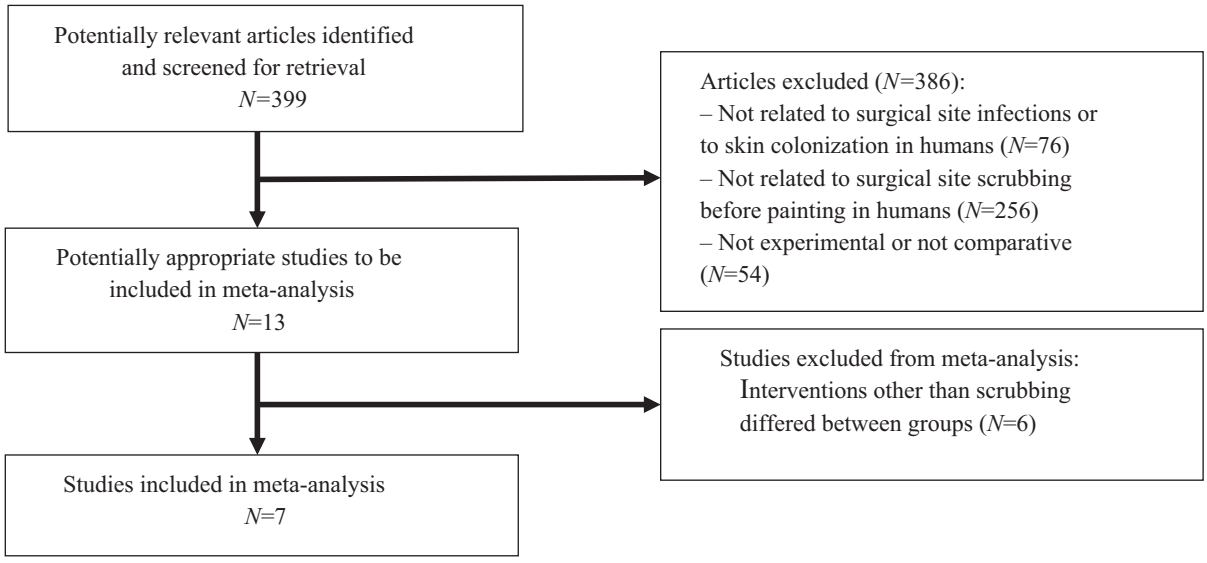

Figure 1. Flow-chart showing the process of identification of studies for inclusion in the systematic review.

Table I
Characteristics of studies included in the meta-analysis of the importance of skin scrubbing for surgical site preparation in the prevention of surgical site infections

Study	Origin	Method	Participants	Interventions	Results	Study limitations
Zdeblick *et al.* 1986[9]	USA	Randomized controlled study	101 patients undergoing elective orthopaedic surgery except total arthroplasty and infected cases	(1) Scrubbing before painting with povidone iodine (2) Painting with povidone iodine	Surgical site infections (wound): (1) 0/45 (2) 0/56	Serious: method not clear, length and method of follow-up not clear
Shirahatti *et al.* 1993[12]	India	Randomized controlled study	135 patients undergoing elective or emergency surgery except anorectal, abscesses and day-care procedures	Shaving the night before surgery, shower with soap in the morning — no antibiotic prophylaxis except for clean surgery and: (1) 10-min scrub with 0.75% chlorhexidine and 1.5% cetrimide, and painting with 1% iodine in 70% alcohol (2) painting with 0.75% chlorhexidine and 1.5% cetrimide, allowed to remain for 2–3 min before being wiped off, 1% iodine and 70% alcohol paint	Surgical site infections (wound): (1) 6/68 (8.82%) (2) 5/67 (7.42%) NS	Very serious: randomization not clear, follow-up not specified, loss to follow-up not specified
Ellenhorn *et al.* 2005[10]	USA	Equivalence randomized controlled study	234 patients of a cancer centre undergoing abdominal surgery	No information given regarding pre-operative shower, removal of gross foreign material from the skin using a dry sponge and tape remover, if necessary, shaving of the surgical site and: (1) 5-min scrub with 0.75% povidone iodine and painting with aqueous 1% povidone iodine (2) painting with aqueous 1% povidone iodine	Surgical site infections (wound): (1) 12/115 = 10.4% (2) 12/119 = 10.1% No difference between groups ($P = 0.078$)	Serious: method not clear and follow-up of 30 days but terms not clear
Moen *et al.* 2002[17]	USA	Parallel trial, matched groups	60 patients undergoing vaginal surgery	One site of the abdomen scrubbed and painted with an aqueous iodophor soap (10%) for 5 min. The other side received 5% povidone iodine spray. No information given regarding pre-operative shower	Proportion of cultures without bacterial growth: 82% (95% CI 72–93) 3 min after the spray and 83% (95% CI 73–93) after scrubbing	Serious: no antiseptic inactivation

Ostrander *et al.* 2003[18]	USA	Randomized controlled study	50 foot or ankle operations in two hospitals	All patients received 1 g cefazolin intravenously 1 h pre-operatively: (1) painting with 1% povidone iodine gel (2) scrubbing with 0.75% povidone iodine and painting with 1% povidone iodine	Positive skin cultures (after skin preparation and draping) Hallucal nail fold: (1) 19/25 (2) 21/25 Web spaces between the second and third digits and between the fourth and fifth digits: (1) 17/25 (2) 19/25 Anterior part of tibia (1) 4/25 (2) 7/25	Serious: no antiseptic inactivation, randomization and blinding not clear
Cheng *et al.* 2009[16]	UK	Parallel trial, matched groups/randomization of the solution. Painting on treated foot, scrubbing before painting on the other foot	50 patients undergoing foot surgery	(1) Alcoholic betadine (1% available iodine): (1A) painting (1B) scrubbing with a brush and painting (2) 0.5% chlorhexidine gluconate in 70% alcohol: (2A) painting (2B) scrubbing with a brush and painting	Positive skin cultures Hallucal nail fold: (1A) 2/25 (1B) 3/25 (2A) 1/25 (2B) 1/25 Interdigital web spaces: (1A) 5/25 (1B) 1/25 (2A) 2/25 (2B) 3/25 Dorsal aspect of the first metatarsophalangeal joint: (1A) 2/25 (1B) 0/25 (2A) 2/25 (2B) 0/25	Serious: blinding not clear, no antiseptic inactivation
Ramirez-Arcos *et al.* 2010[19]	Canada	Randomized controlled study. Randomization of the arm for each method (study designed for blood donors)	256 volunteer subjects. (Two phases: (1) vs (2), then (2) vs (3); 3 weeks washout	(1) Scrubbing with 2% chlorhexidine gluconate and 70% isopropyl alcohol followed by application of 2% chlorhexidine gluconate and 70% isopropyl alcohol. (2) and (3) application of a swab stick containing 70% isopropyl alcohol and 2% chlorhexidine	Positive skin cultures Phase 1: (1) 12/128 (2) 13/128 Phase 2: (1) 8/128 (3) 16/128	Serious: method not clear, different methods of antisepsis application

NS, not significant; CI, confidence interval.

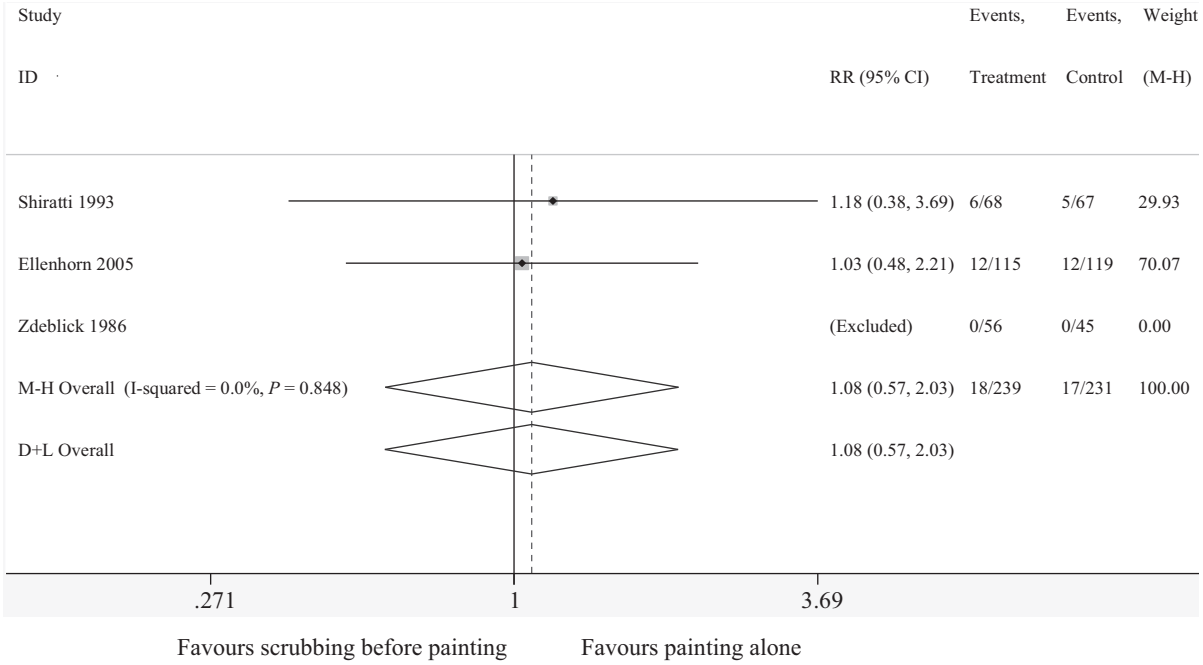

Figure 2. Meta-analysis of relative risk (RR) of surgical site infection for scrubbing before painting compared with painting alone. CI, confidence interval.

Evaluation) method.[13] The criteria for randomized studies were: allocation concealment, blinding (for patients, caregivers, outcome assessment and statistician), loss of follow-up, intention-to-treat analysis when required, selective outcome reporting, and other bias. The criteria for observational studies were: selection of exposed and non-exposed cohorts drawn from the same population, overmatching or undermatching for case–control studies, adequate and same measurement of the exposure and outcome for all patients, measurement of confounding factors, failure to match for confounding factors and/or lack of adjustment in statistical analysis, adequate follow-up, and other bias. In cases of

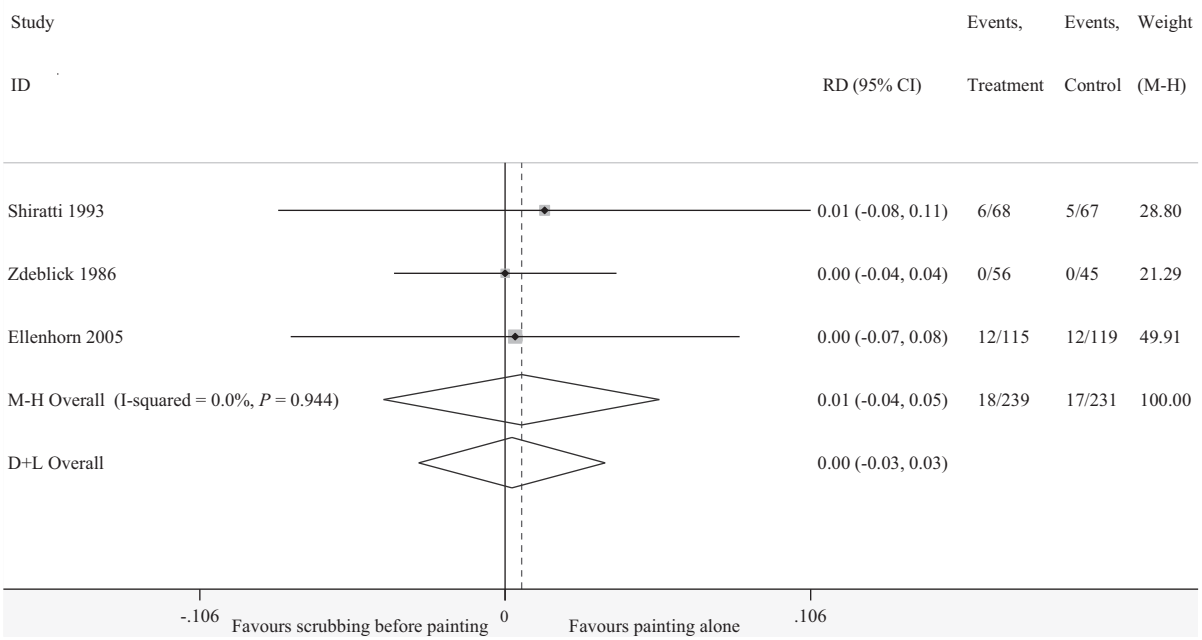

Figure 3. Meta-analysis of absolute risk difference (RD) in surgical site infection between scrubbing before painting compared with painting alone. CI, confidence interval.

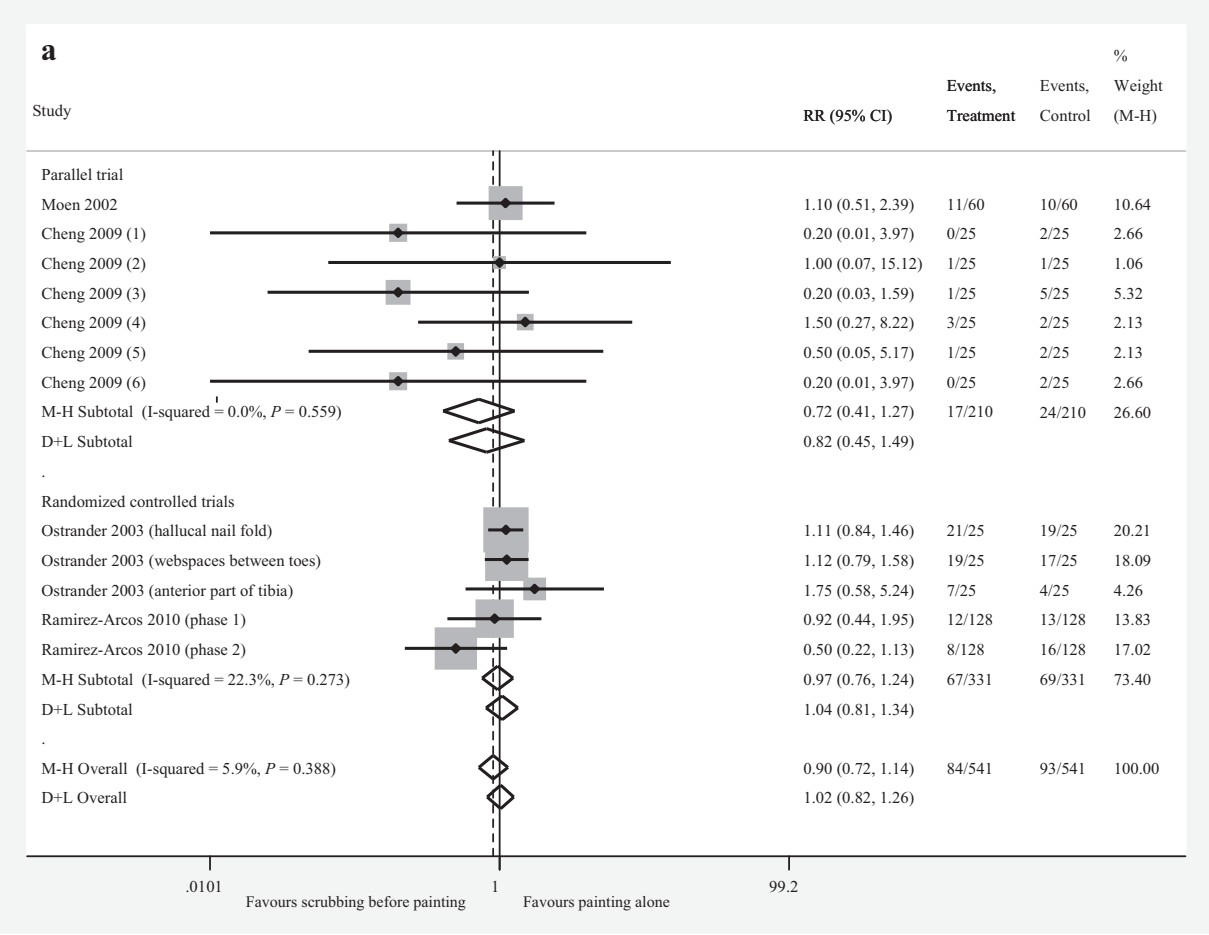

Figure 4. Meta-analysis of relative risk (RR) of positive skin culture for scrubbing before painting compared with painting alone. (a) Results of meta-analysis according to the design of the trial. (b) Funnel plot. CI, Confidence interval. Detail from Cheng *et al.* 2009[16]: (1) hallucal nail fold — povidone iodine; (2) hallucal nail fold — chlorhexidine; (3) interdigital wab spaces — povidone iodine; (4) interdigital wab spaces — chlorhexidine; (5) dorsal aspect of the 1st metatarsophalangeal joint — povidone iodine; (6) dorsal aspect of the 1st metatarsophalangeal joint — chlorhexidine.

discordance between the two researchers, the study limitations were defined by the group.

Meta-analyses

Data on surgical site infections and skin colonization were extracted from selected studies, and analysed using Stata Version 10 (Stata Corp., College Station, TX, USA), metan add-on[14] and Open-Metanalyst[15] for leave-one-out meta-analyses. Relative risks were calculated initially. For surgical site infections, absolute risk differences were calculated to take into account those studies with zero cases. A fixed-effect model (Mantel Haenszel method) and a random-effect model (DerSimonian and Laird method) were tested. If heterogeneity was

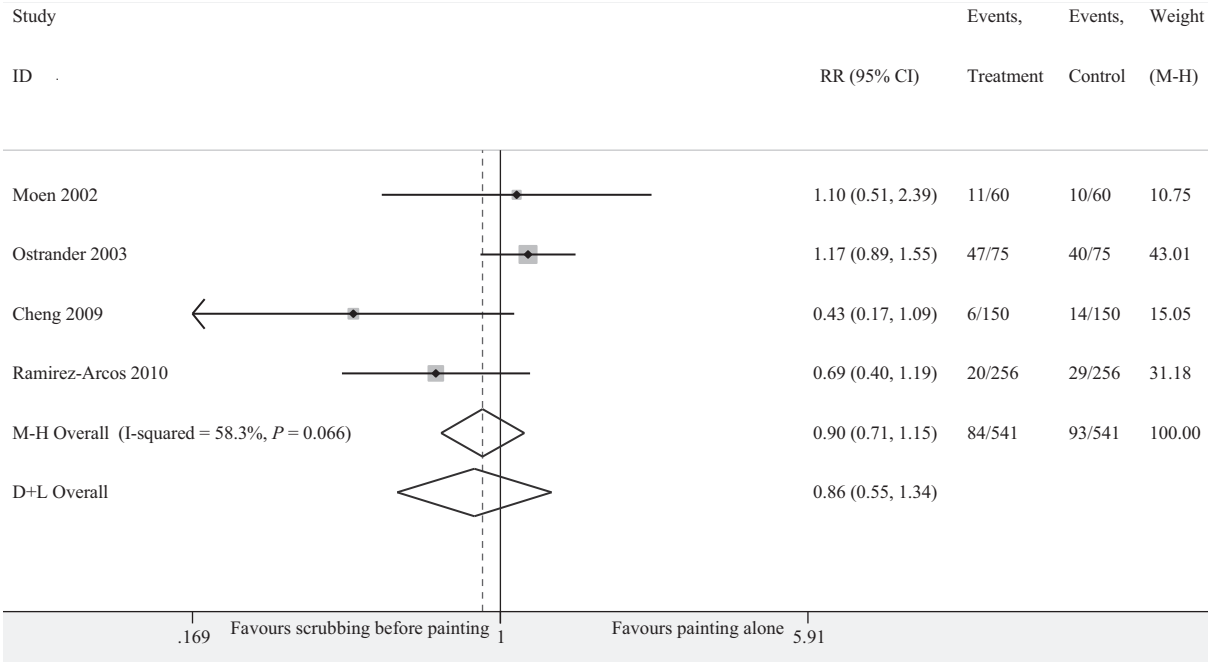

Figure 5. Meta-analysis by aggregating data by study. RR, relative risk; CI, confidence interval.

detected by the I^2 and χ^2 heterogeneity tests, the random-effect model was selected. Otherwise, the fixed-effect model was used. The sensitivity analysis was conducted by removing non-randomized controlled trials. A second meta-analysis was performed by regrouping data by study (for studies that reported testing several sites per patient, and for one study with two phases with different antiseptics for the group receiving painting alone). It was assumed that data were not correlated in these studies because individual data were not available in order to take the covariance into account. Finally, leave-one-out analyses were conducted. The potential for publication bias was explored using a funnel plot.

Results

Three hundred and ninety-nine studies were identified (Figure 1). The manual search revealed no new articles. Seven studies were selected for inclusion in this meta-analysis.[9,10,12,16–19] Of the exclusions, 76 studies were not related to surgical site infections or skin colonization, 256 studies were not related to surgical site scrubbing in humans, six studies involved interventions other than scrubbing that differed between groups or were not comparative, and 54 studies were not experimental (e.g. literature reviews or outbreak investigations). Of the seven studies included in this meta-analysis, surgical site infection outcome was only studied in three studies (270 patients).[9,10,12] In the other four studies (1082 patients), the outcome was the number of positive skin cultures.[16–19] The study published by Zdeblick *et al.* also investigated skin colonization but the proportion of positive cultures was not known.[9] The characteristics and limitations of the selected studies are shown in Table I. Study limitations were equally serious for studies investigating surgical site infection outcome and positive skin culture outcome.

No surgical site infections occurred in one of the three selected studies (Figures 2 and 3).[9] Therefore, this study was excluded from the meta-analysis of relative risk. The relative risk of surgical site infection for scrubbing before painting compared with painting alone was 1.08 [95% confidence interval (CI) 0.57–2.03]. The absolute risk difference for scrubbing before painting compared with painting alone was 0.6% (95% CI −4.2–5.3%). No heterogeneity was observed. Leave-one-out analysis revealed no significant changes in risk differences. The funnel plot (not shown) was difficult to interpret because of the small number of studies included, but it did not suggest publication bias.

For the positive skin culture outcome, the meta-analysis of the four selected studies and the sensitivity analyses are shown in Figures 4 and 5. The relative risk of a positive skin culture for scrubbing before painting compared with painting alone was 0.90 (95% CI 0.72–1.14) when the different sites and phases were studied separately for studies with several sites tested per patient or the study with two phases (Figure 4). Low heterogeneity was observed (5.9%, $P = 0.388$). Sensitivity analyses showed similar results. Leave-one-out analysis revealed no significant changes in relative risk. Aggregating the data by study (Figure 5), the relative risk of a positive skin culture for scrubbing before painting compared with painting alone was 0.86 (95% CI 0.5–1.34). The random-effect model was used as important heterogeneity was observed (58.3%, $P = 0.06$). Leave-one-out analysis for aggregated data did not show any significant change in relative risk. When the studies by Moen *et al.*[17] and Cheng *et al.*[16] were eliminated and only randomized controlled trials were examined, the relative risk was 0.97 (95% CI 0.76 −1.24) for the fixed-effect model (Figure 4). Moderate heterogeneity was observed (22.3%, $P = 0.273$). The

relative risk with the random-effect model was 1.04 (95% CI 0.81–1.34). The funnel plot (Figure 4b) did not suggest publication bias.

Only the study by Ramirez-Arcos and Goldman reported skin reactions.[19] These occurred in three of 382 patients who underwent scrubbing (128 patients in the scrubbing before painting group described in this meta-analysis and 128 patients who had the same scrub-and-paint preparation in another phase of the study by Ramirez-Arcos *et al.*, not described here because it compared two scrub-and-paint methods). Ramirez-Arcos and Goldman also compared two groups that received painting alone (each $N = 128$), using a swab stick containing 70% isopropyl alcohol and 2% chlorhexidine (Solu IV stick, Solumed, Laval, Quebec, Canada).[19] One patient in the first group and three patients in the second group experienced skin reactions. The authors stated that there were too few events to compare the methods. The present authors performed a Fisher's exact test on these data by aggregating the two techniques, and confirmed that there was no significant difference between them (3/382 vs 4/382; $P = 1$).

Discussion

Very few relevant articles about surgical site scrubbing to reduce surgical site infections or skin colonization were found in the literature. Meta-analysis of these articles did not indicate superiority of one technique over the other, because the CIs of relative risk all contained 1 and the CIs for differences in absolute risk all contained 0. CIs were large: −4.2–5.3% for absolute risk and 0.57–2.03 for relative risk. Thus, they did not allow the exclusion of either a substantial benefit or a substantial deleterious effect of scrubbing before painting. However, the results suggest that scrubbing before painting did not have any effect, as concluded by Ellenhorn *et al.*[10] The large CIs may be due to the small number of patients included in the studies (470) and the small number of events. Thus, a small difference between the groups could not be highlighted, and more patients would be necessary to conclude equivalence. It should be noted that Shirahatti *et al.*[12] compared two techniques, both of which were two-step skin preparations (two-step painting and scrubbing before painting). However, this study was retained in the meta-analysis as the scrub method was longer (10 min) compared with painting alone (approximately 3 min), and there was no mechanical scrubbing in the group who received painting alone.

The duration of scrubbing and the antiseptic used (chlorhexidine or povidone iodine in alcoholic or aqueous solution) varied between studies. This could lead to heterogeneity in the treatment effect, but no heterogeneity was found in this meta-analysis.

The meta-analysis of skin colonization outcome did not reveal any significant effect of scrubbing before painting the surgical site, as the relative risk of a positive skin culture with scrubbing before painting compared with painting alone was 0.90 (95% CI 0.72–1.14). However, these studies do not allow the conclusion that painting alone and scrubbing before painting are equivalent. Moreover, skin colonization is only an indirect criterion for surgical site infection, as it is assumed that a positive skin culture is a risk factor for surgical site infection. In addition, this criterion does not take into account the level of skin colonization, and can be affected by other variables such as sampling methodology and microbiological methods.

Several other studies aimed to compare painting alone with scrubbing before painting, or to compare two surgical site preparation techniques (one including scrubbing, the other not including scrubbing). These studies were not included in this meta-analysis because interventions other than scrubbing varied between groups. For example, the study published by Gilliam and Nelson evaluated 60 patients who underwent prosthetic surgery.[20] This study compared scrubbing before painting with an aqueous iodophor with painting alone using an iodophor and alcohol.[20] As alcohol was only used in one group, the two groups were not comparable in terms of the effect of scrubbing. However, no significant difference was observed between the two groups in terms of skin colonization. Saltzmann *et al.* compared surgical site infections in a randomized controlled trial that included 150 patients scheduled for shoulder surgery.[21] Three skin preparations were compared: (1) painting with 2% chlorhexidine and 70% isopropyl alcohol, (2) painting with 0.7% iodophor and 74% isopropyl alcohol, and (3) scrubbing before painting with povidone iodine (scrubbing with iodine 0.75% and painting with iodine 1%). No surgical site infections were observed, but this outcome was not measured specifically. Positive skin cultures occurred more frequently in the group who underwent scrubbing before painting compared with the other two groups. It is important to note that there was no mention of antiseptic inactivation. This could have led to bias in the evaluation of skin colonization. Other studies that compared painting alone with scrubbing before painting and had other interventions that differed between the groups showed no significant difference between the two groups.[22–25]

These studies, like the studies included in this meta-analysis, suggest that there may be no need for surgical site scrubbing. However, these studies were not designed to answer this question, as shown by the fact that interventions other than scrubbing differed between the groups. Caution is also required when interpreting the results of this meta-analysis because the number of patients was too small to draw any conclusions with a sufficient equivalence margin. In addition, the studies included in this meta-analysis had serious or very serious limitations. A further limitation is the absence of information about pre-operative showers in some studies. A pre-operative shower could have the same effect as surgical site scrubbing, and results could vary depending on whether or not the patient had a pre-operative shower. Subgroup meta-analyses would be interesting, but there were insufficient studies to make this possible and information about taking a pre-operative shower was not given systematically.

Further research is needed to draw conclusions about the lack of efficacy of surgical site scrubbing in the prevention of surgical site infections. These studies need to include enough patients to allow a reasonable equivalence margin.[11] Conversely, the current scientific literature included in this meta-analysis does not impose recommendations for surgical site scrubbing before painting, as no studies have highlighted any associated benefits. The lack of efficacy could be due to the release of micro-organisms from pores and follicles.[9] Dispensing with surgical site scrubbing could save time as this step is time-consuming (up to 10 min[12]). However, it is

necessary to ensure that the product used for painting has sufficient contact time.[26] Indeed, in addition to providing detersive cleaning, scrubbing ensures prolonged contact of the skin with an antiseptic, as the product used is generally an antiseptic. Conversely, elimination of surgical site scrubbing before antisepsis could result in an improvement in the antisepsis contact time, as the antisepsis would be the only skin preparation performed in the operating room before surgery. This step would seem to be more important on the one hand, but on the other hand, the duration of skin preparation would be reduced by eliminating the scrub phase. Elimination of surgical site scrubbing would also cut costs, given the reduced use of antiseptic soap. Finally, it could potentially lead to fewer adverse effects as the skin would be exposed to fewer products and to less rubbing, thus reducing skin irritation.

It is believed that there is no need to scrub the surgical site if the skin is visibly clean and/or if patients have had a preoperative shower.

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